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Descriptive study of undergraduate students' attitudes towards open education practices, efficacy, course achievement, and demographic characteristics

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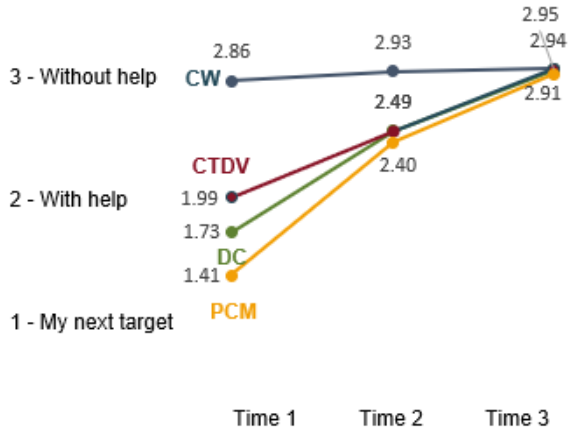
EXECUTIVE SUMMARY

Students' perceptions of open educational resources, efficacy of course constructs, course achievement, and demographic characteristics were explored within a study aimed to understand students' relationships across beliefs towards open educational practices/resources and other features. During Fall 2020, a digital citizenship course was taught utilizing open educational practices (i.e., use of open educational resources such as videos, readings and case studies as well as used open source software such as R and Datacamp). Learning objectives for the course focused on increasing students' digital literacy to understand truthfulness of claims and inferences made using quantitative, statistical, and computational analysis of big data. Students enrolled in the course were asked to participate in the study and provided consent to researchers to use the following data: 1) efficacy data of students' self-ratings in their ability to complete tasks related to a) digital citizenship, b) collaborative work and "play with ideas", c) critical, quantitative thinking, and data visualization, and d) programming / computational methods; 2) survey data on students perceptions to OEP/OER; 3) course grade; and 4) demographic data related to sex/gender; race/ethnicity; socio-economic status (financial aid). Sixteen out of 37 students gave permission to include data within the study, with 14 of the 16 students allowing researchers to use all data sources.

The following is an overview of major findings from the study:



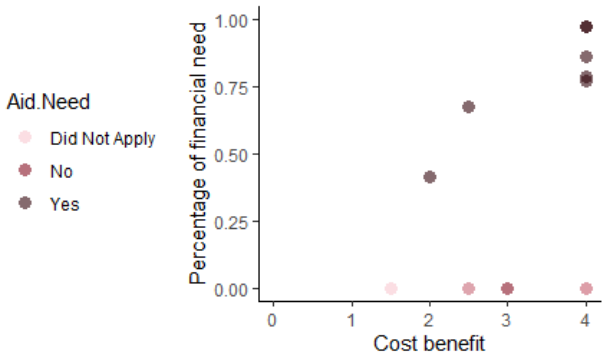
Mean scores at times 1, 2 and 3 for digital citizenship (DC), collaborative work and play with ideas (CW), critical, quantitative thinking and data visualization (CTDV), and programming and computational methods (PCM) demonstrate that on average students were less efficacious at the start of the semester with tasks related to DC, CTDV, and PCM, but had very strong efficacy at the end of the semester across all course constructs.

All students indicated at least some benefit that 1) OER materials supported learning outcomes; 2) OER increased awareness for finding additional information about course material; and 3) OER provided savings through the use of open software. The following comments were provided by students:

> Remote classes with open education practices creates a more equal playing field. This is important since some students were on campus and off campus meaning their access to certain materials differed.

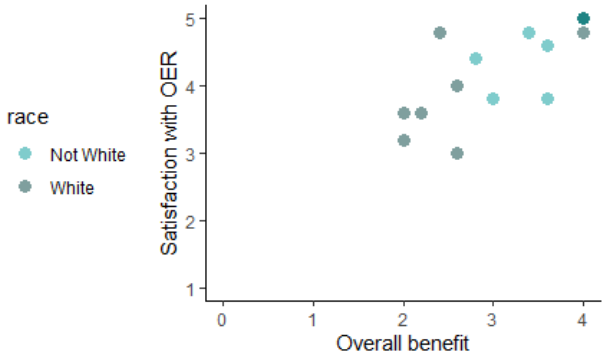
> Easy access to resources makes sure that everyone get the same information. This helps a lot in teaching and collaborating process at class. Because if the materials such as textbooks need to be purchased or borrowed from library, probably different people would get the different edition.

The percentage of financial need is positively correlated with increased perceptions to the cost savings benefit of OER (r = .34). The percentage of financial need is also positively related to efficacious beliefs of ability to complete collaborative work tasks without help at time 3 (r = .34).

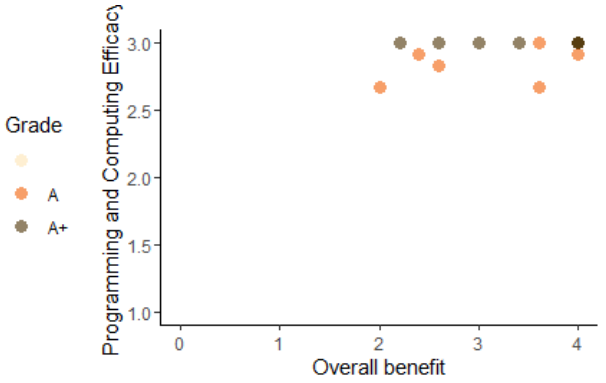


The perceptions of the cost benefits for OER are fairly spread out across individuals who did not need or did not apply for financial aid; whereas individuals with the highest financial aid need tended to cluster around a score of 'a great extent of cost benefits'. **(Figure above)**

The relationship between overall benefit of OER to race shows a pattern where those who are not White were more likely to rate the overall benefit of OER higher than those who were White. **(Figure right)**



The only significant relationship across efficacy variables and perceptions towards OER appears with students' beliefs in their ability to complete tasks related to Programming and Computational Methods at the end of the semester (r = .31).



Students who received an A+ in the course reported efficacy of being able to complete all programming and computational method (PCM) tasks without help – but spread out across overall satisfaction scores. **(Figure above)**

INTRODUCTION.

The purpose of this study is to explore the relationships for students' perceptions of OER, efficacy of course constructs, course achievement, and demographic characteristics. During Fall 2020, a digital citizenship course was taught utilizing open educational practices (i.e., use of open educational resources such as videos, readings and case studies as well as used open-source software such as R and datacamp). Learning objectives for the course focused on increasing students' digital literacy to understand truthfulness of claims and inferences made using quantitative, statistical, and computational analysis of big data. Students enrolled in the course were asked to participate in a study designed to understand the impact of open education initiatives when utilized within an undergraduate course.

During the course, students were asked to keep an efficacy portfolio where they would indicate their ability to complete tasks related to:

- Digital citizenship,
- Collaborative work and "play with ideas",
- Critical, quantitative thinking, and data visualization, and
- Programming / computational methods.

Students assessed their belief in their ability to complete a task using a scale of 3 – without help, 2 – with help, and 1 – my next target/goal at the start, middle and end of the course.

METHODS

The study was conducted with students enrolled in a digital citizenship course at a four-year, small, highly residential private not-for-profit institution located within the Northeastern United States. An electronic survey for consent and students' attitudes towards open educational practices was administered to students at the end of the digital citizenship course (December 2020). All 37 students enrolled in the course were asked to provide consent to use multiple data sources, including:

- Submissions from students' completed efficacy portfolio in which students were asked to indicate their ability to complete numerous tasks across four constructs (e.g., digital citizenship, collaborative work, critical thinking, and programming).
- Course grades within the digital citizenship course
- Institutional data related to sex/gender; race/ethnicity; socio-economic status (financial aid), etc., and
- Survey data on students' attitudes towards OEP

Overall consent rates are provided in Table 1.

Table 1. Consent across study components

	Efficacy portfolio	Grades	Institutional Data	Survey
Consent	16 (43%)	15 (40%)	16 (43%)	16 (43%)
No consent	2 (5%)	3 (8%)	2 (5%)	2 (5%)
No response	19 (51%)	19 (51%)	19 (51%)	19 (51%)

Note. Percentages do not add to 100% due to rounding. One student who indicated consent to complete the survey did not provide responses to survey questions.

Participants

Sixteen out of 37 students gave permission to include institutional data related to sex/gender; race/ethnicity; socio-economic status (financial aid) within the study. Student characteristics are provided in Table 2. Of these 16 students, 9 (56%) were female and 7 (43%) were male – similar counts were provided for gender, except data was missing for two students whose sex were identified as female (n = 1) and male (n = 1). The majority of the students were White (10 or 62.5%), with 3 students identified as international, 1 student as Asian, 1 student as Hispanic and 1 student as Black or African American. Of these 16 students, 2 are first generation students.

The estimated cost of attendance for students at the institution includes costs for tuition, fees, books and supplies, variable expenses, and health insurance. This results in slight fluctuations for each students' estimated cost of attendance. For these 16 students, cost of attendance ranged from $73,528 to $78,733 with an average cost of $75,662 ($SD$ = $1,811). Eight out of these 16 students had financial need – 3 students did not meet the criteria for financial need and 5 students did not apply. A percentage was created for each student to compare the amount of financial need to their estimated cost of attendance. The range of financial need for these eight students ranged from 41.40% to 97.32% with an average percentage need of 74.56% (SD = 20.53%).

Table 2. Demographic characteristics of study participants

Sex and Gender	Sex	Gender
Female	9	8
Male	7	6
Not provided		2

First generation status	
No	14
Yes	2

Race provided for IPEDS classification	
Asian	1
Black or African American	1
Hispanic	1
International	3
White	10

Financial Need	
Did Not Apply	5
No	3
Yes	8

Expected graduation year	
2021	5
2022	1
2024	10

Instruments

The efficacy portfolio was designed for students to assess their beliefs in their abilities related to a) digital citizenship, b) collaborative work and play with ideas, c) critical/quantitative thinking and data visualization, and d) programming and computational methods from the start to conclusion of the semester. A copy of the instrument is provided in Appendix A. The assessment asked students if they 'can do' 6 tasks related to 'digital citizenship', 9 tasks related to 'collaborative work and play with ideas', 11 tasks related to 'critical, quantitative thinking and data visualization', and 12 tasks related to 'programming and computational methods'.

The student survey for open education practices was created to understand students' perceptions for benefits of OEP and included 20 items from a Perceptions' Survey[1] in which six dimensions of OER were assessed – Appendix A. The following scales were created from survey items:

- **OER Cost Benefit factor**. Average agreement of responses across 2 items:
    - Using OER provided savings from no textbook cost.
    - Using OER provided savings by using open software (datacamp – R, etc.)
- **OER Learning Benefit factor**. Average agreement of responses across 3 items:
    - Using OER increased awareness for finding additional, trustworthy information about course material.
    - The OER materials provided in the course supported learning outcomes.
    - I expect to reuse or utilize learning materials from this course.
- **OER Overall Benefit factor**. Average agreement across 5 items included within the OER Cost Benefit factor and the OER Learning Benefit Factor.

- **Satisfaction with OER**. Average agreement across 5 items:
    - I enjoy learning in an environment that incorporates OER.
    - OER make me feel more engaged with my learning.
    - If given a choice, I prefer learning using OER.
    - OER directly improve the quality of my learning experience in this course.
    - There is a match between the OER content and specific learning objectives of this course.
- **Textbook preference**. Average agreement across 3 items:
    - If given a choice, I prefer learning using a textbook.
    - Textbooks help me understand topics better than OER.
    - OER does not offer any advantages to me.
- **OER preference**. Average agreement across 2 items:
    - I believe I can learn more through OER than through a textbook.
    - OER help me understand topics better than textbooks.
- **Recommend OER**. Average agreement across 2 items:
    - I would like to take more courses that use OER.
    - I would recommend a course that uses OER to others.

[1] Rowell, J. L. (2015). Student perceptions: Teaching and Learning with Open Educational Resources. *Electronic Theses and Dissertations.* Retrieved from https://dc.etsu.edu/cgi/viewcontent.cgi?article=3925&context=etd.

- **Course Learning**. Average agreement across 5 items:
    - I have changed my attitudes about this course subject matter as a result of this course.
    - I feel more self-reliant as a result of this course.
    - I feel I am a more sophisticated thinker as a result of this course.
    - Overall, the learning experience in this course was positive.
    - Overall, the quality of the OER content of this course was excellent.

Appendix B (Benefit scales) and Appendix C (Agreement scales) include correlational data across items within each scale, a correlational plot, and reliability analysis. This information was used to justify the creation of mean composite scores for each scale which are used within the analyses. Reliability coefficients for each scale are provided in Table 3. Overall reliabilities tend to justify the creation of scales (except for the 2 items scales for OER preference and Recommend OER)**Table 1**. Further studies with a larger sample size would be needed to better understand measurement properties of the instrument. However, reliability is a property of scores on an instrument, not an inherent measurement of a test and should be computed for all uses of the instrument and sample groups to justify the use of scales within any research study.

Table 3. Reliability coefficients for OER perception scales

Scale	No. of items	Cronbach alpha	
		Raw	Standardized
OER Cost Benefit	2	.65	.71
OER Learning Benefit	3	.67	.71
OER Overall Benefit	5	.76	.79
Satisfaction with OER	5	.91	.91
Textbook preference	3	.75	.75
OER preference	2	.45	.45
Recommend OER	2	.45	.45
Course Learning	5	.82	.82

Note. Raw alpha uses covariance and is sensitive to differences in item variances. Standardized alpha uses correlations and is not sensitive to differences in item variances.

Appendix D includes tables for each efficacy scale which includes the mean ratings across time for each item within an efficacy scale and counts for students indicating they can accomplish the task without help at each time period. A large number of students indicated they could accomplish tasks without help at the second and third time periods, which affects the computational reliability for examining consistency across the scale items. For purposes of this study, mean composite scores were computed at each time point for 1) digital citizenship, 2) collaborative work and play with ideas, 3) critical, quantitative thinking and data visualization, and 4) programming and computational methods.

RESULTS

Results from the survey, efficacy portfolio and relationships across variables used in the study are provided to explore relationships within and across constructs.

Survey Findings

All students indicated at least some benefit for 1) The OER materials provided in the course supported learning outcomes; 2) Using OER increased awareness for finding additional, trustworthy information about course material; and 3) Using OER provided savings by using open software – see Figure 1. Only 1 of the 15 responses indicated no benefit for 1) I expect to reuse or utilize learning materials from this course and 2) using OER provided savings from no textbook cost.

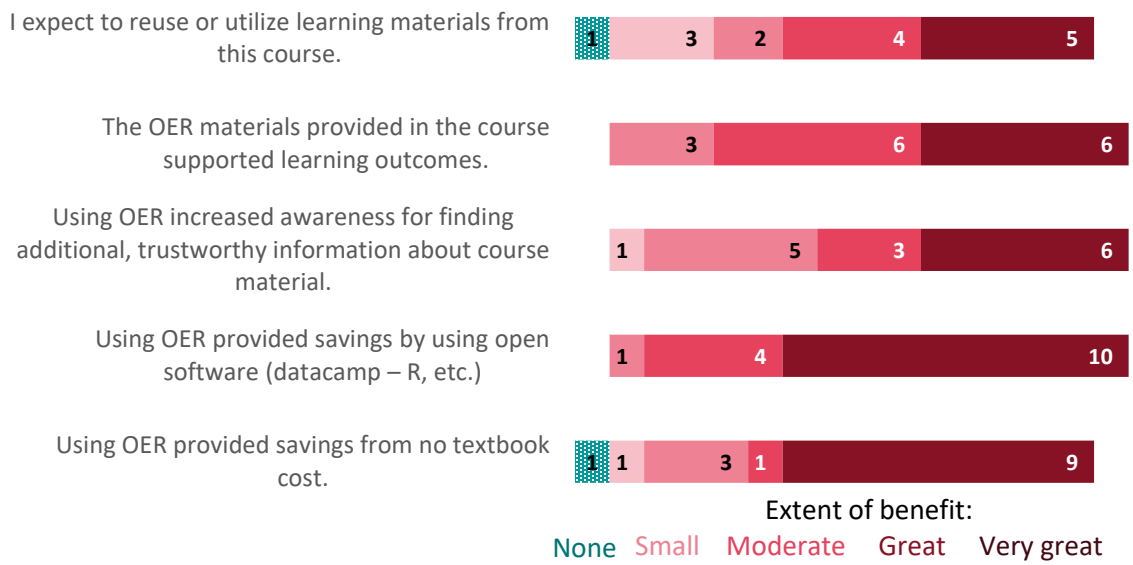


Figure 1. Level of benefit indicated by students with respect to use of OER in Calling Bull Course

Students were also asked to provide open-ended feedback to the question: As a student, what benefits (if any) do you feel resulted from completing a course which engaged open education practices? The following are the students open-ended responses to this question:

- Remote classes with open education practices creates a more equal playing field. This is important since some students were on campus and off campus meaning their access to certain materials differed.
- Easy access to resources makes sure that everyone gets the same information. This helps a lot in teaching and collaborating process at class. Because if the materials such as textbooks need to be purchased or borrowed from library, probably different people would get the different edition.
- Saving money and learning of new avenues in which to further my learning (i.e., DataCamp).
- Availability and flexibility of OER.
- It gave me a better view of the world and helped me connect the course to the world.
- I was given all of the tools I needed in order to succeed in this course.
- They made class more engaging and fun
- It saved money and was convenient.
- Learned how to solve everyday problems on our own.

Figure 2 is provided to demonstrate the overall agreement with 20 items related to perceptions towards OER and OEP.

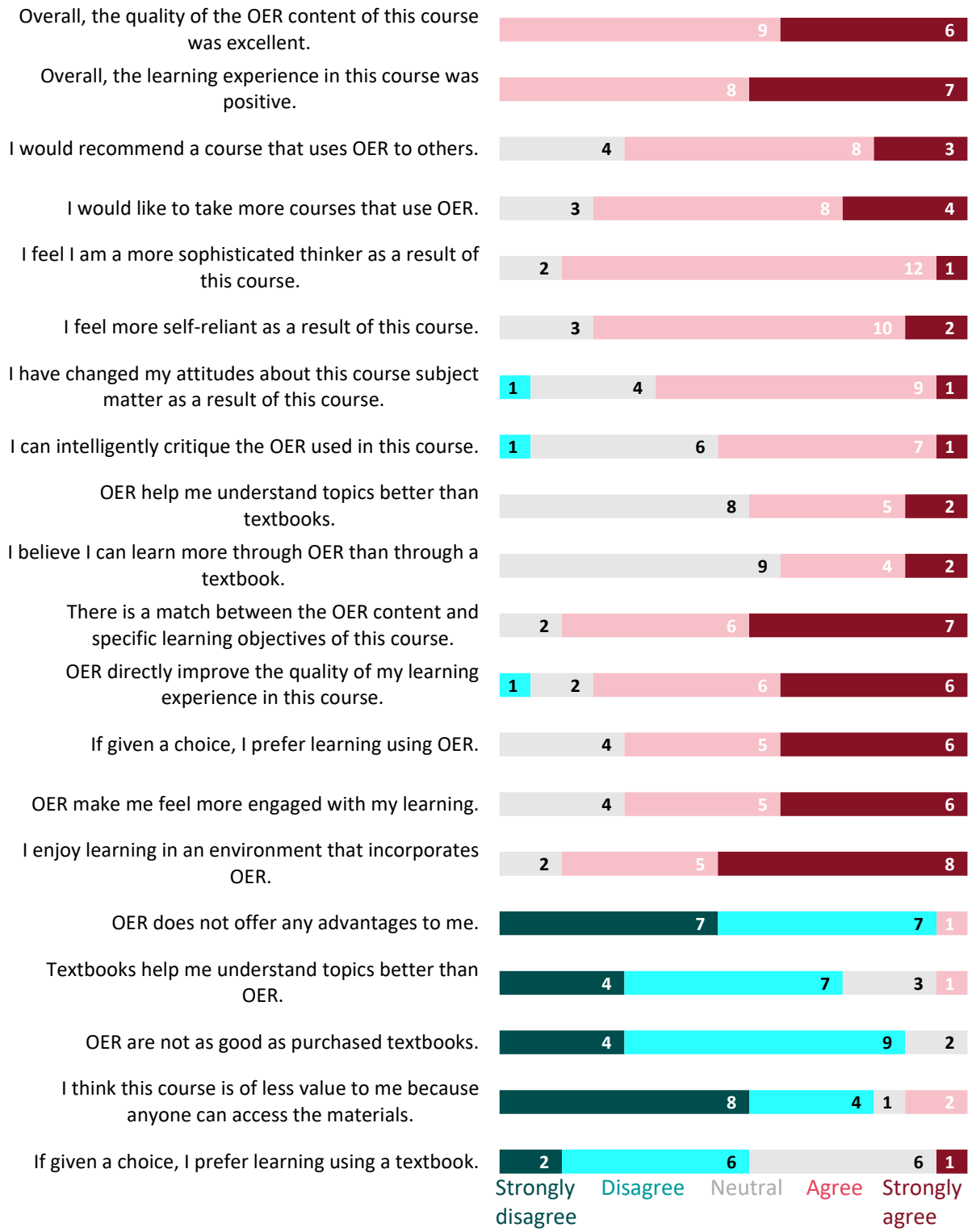


Figure 2. Level of agreement indicated by students for perceptions towards OER

Changes in Students' Efficacy across Time

An average score across all three time points for digital citizenship (DC), collaborative work and play with ideas (CW), critical, quantitative thinking and data visualization (CTDV), and programming and computational methods (PCM) was computed for each student by summing scores for each item within the scale and dividing by the number of items. Descriptive statistics of students' scores for each scale are provided in Table 4. Figure 3 shows the mean scores for each scale at time points 1, 2, and 3, where 1 represents students indicated the item was their next target, 2 indicates they could do the task with help, and 3 represents they could do the task without help.

Table 4. Descriptive statistics of mean scores for efficacy scales across time

Scale	Timing	Min	Mean	SD	Median	Max
Digital Citizenship (DC)	Time 1	1.00	1.73	0.46	1.83	2.33
	Time 2	1.80	2.49	0.35	2.50	3.00
	Time 3	2.67	2.94	0.11	3.00	3.00
Collaborative Work and Play with Ideas (CW)	Time 1	2.44	2.86	0.18	2.94	3.00
	Time 2	2.56	2.93	0.12	3.00	3.00
	Time 3	2.50	2.95	0.14	3.00	3.00
Critical, Quantitative Thinking & Data Visualization (CTDV)	Time 1	1.00	1.99	0.54	2.09	2.55
	Time 2	1.91	2.49	0.30	2.45	3.00
	Time 3	2.73	2.95	0.08	3.00	3.00
Programming and Computational Methods (PCM)	Time 1	1.00	1.41	0.38	1.29	2.17
	Time 2	1.67	2.40	0.25	2.42	2.67
	Time 3	2.67	2.91	0.13	3.00	3.00

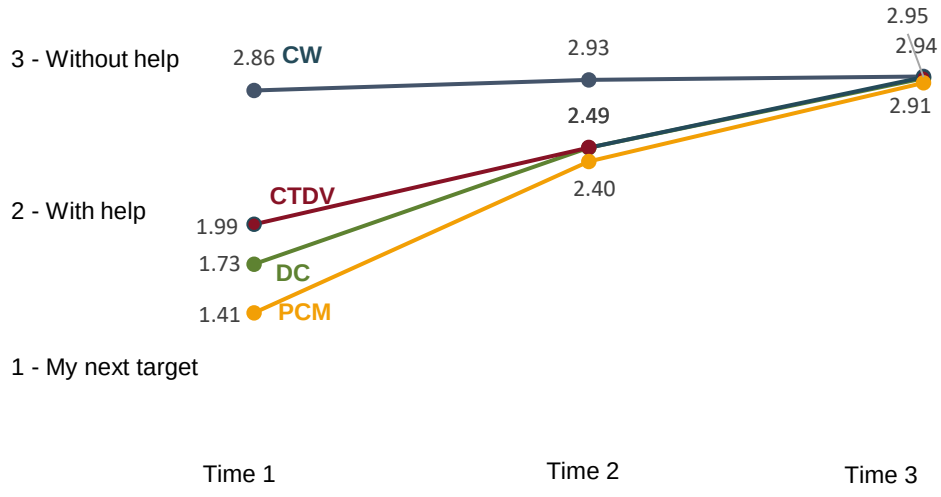


Figure 3. Mean scores at times 1, 2 and 3 for digital citizenship (DC), collaborative work and play with ideas (CW), critical, quantitative thinking and data visualization (CTDV), and programming and computational methods (PCM)

Relationships across efficacy scales, OER perceptions, grades, and student characteristics

Correlations and scatterplots were used to explore relationships across study variables. Figure 4 is a correlational plot used to show the strength of correlation across study variables, and Table 5 shows the correlation values. (A description of the variable names is provided in Appendix E.)

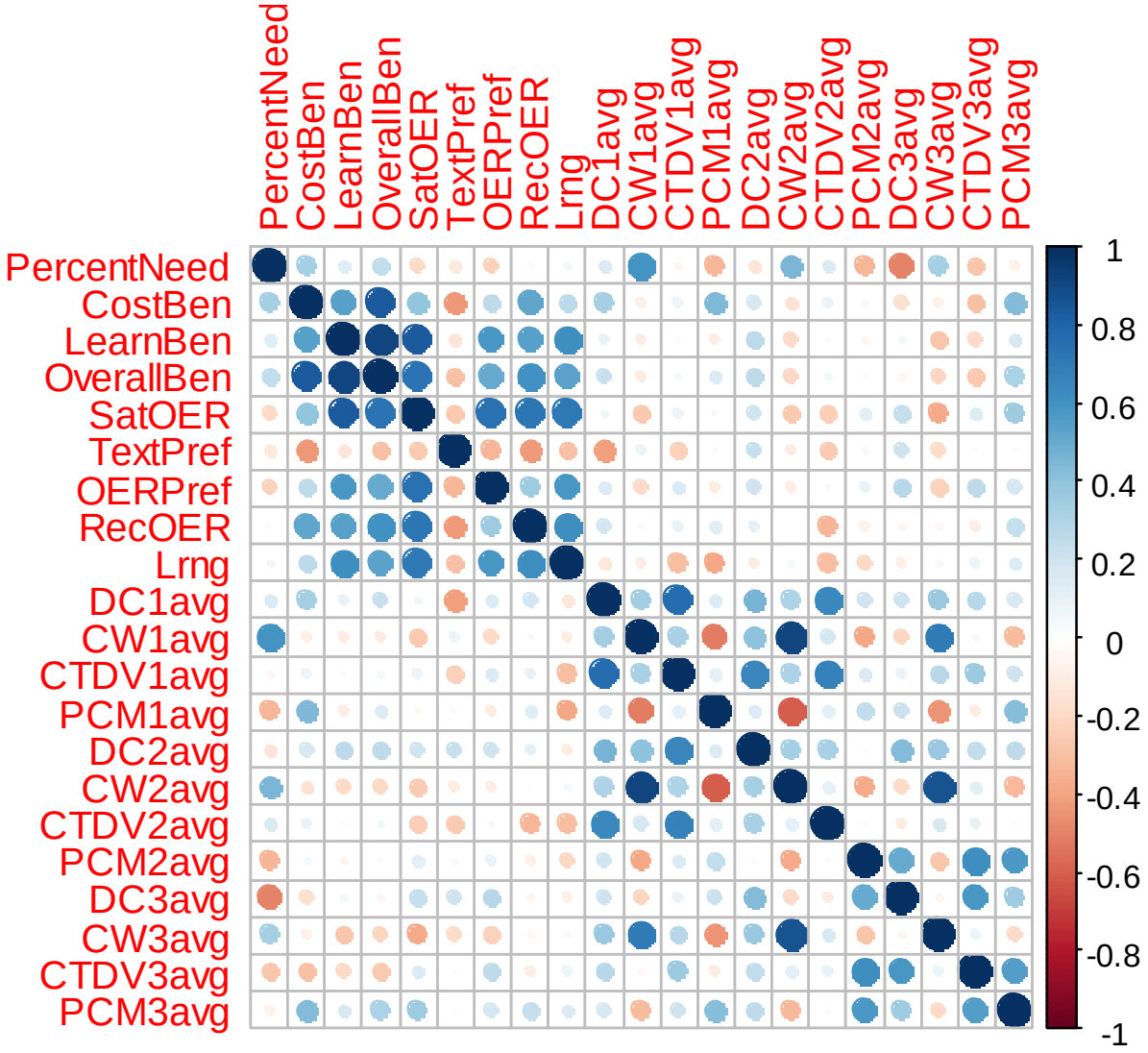


Figure 4. Correlation plot across perceptions, efficacy scales, grade, and characteristics.

Table 5. Correlation plot across perceptions, efficacy scales, grade, and characteristics

	% Need	Cost Ben	Learn Ben	Overall Ben	SatOER	Text Pref	OER Pref	RecOER	Lrng	DC1M	CW1M	CTDV1M	PCM1M	DC2M	CW2M	CTDV2M	PCM2M	DC3M	CW3M	CTDV3M	PCM3M
% Need	1.00	.34	.14	.25	-.20	-.11	-.22	.02	-.08	.16	.60	-.05	-.33	-.14	.46	.16	-.34	-.49	.34	-.27	-.07
Cost Ben		1.00	.55	.83	.40	-.43	.26	.52	.22	.34	-.09	.07	.45	.16	-.15	.09	.04	-.17	-.07	-.29	.43
Learn Ben			1.00	.92	.83	-.13	.59	.54	.56	.10	-.09	.03	-.09	.27	-.20	.02	-.06	.06	-.27	-.19	.16
OverallBen				1.00	.74	-.29	.51	.60	.47	.22	-.10	.05	.15	.26	-.20	.06	-.02	-.04	-.21	-.27	.31
Sat OER					1.00	-.27	.74	.73	.70	.06	-.26	.07	-.03	.20	-.25	-.24	.12	.24	-.38	.15	.35
Text Pref						1.00	-.34	-.42	-.31	-.42	.08	-.24	-.03	.22	-.10	-.26	.04	.21	-.19	.01	.02
OER Pref							1.00	.35	.62	.15	-.19	.15	-.10	.20	-.09	.03	.09	.27	-.23	.25	.17
Rec OER								1.00	.61	.19	-.03	.10	.13	.11	.00	-.33	-.07	-.06	-.05	-.10	.23
Lrng									1.00	-.08	-.11	-.28	-.27	.01	.03	-.30	-.26	.09	.09	.05	.14
DC1M										1.00	.34	.77	.14	.47	.31	.65	.20	.20	.38	.27	.16
CW1avg											1.00	.32	-.52	.40	.91	.18	-.39	-.21	.70	-.03	-.32
CTDV1M												1.00	.11	.65	.31	.68	.15	.08	.28	.36	.21
PCM1M													1.00	.14	-.61	.11	.24	.22	-.45	-.11	.43
DC2M														1.00	.34	.33	-.01	.43	.37	.25	.26
CW2M															1.00	.11	-.37	-.19	.86	.11	-.33
CTDV2M																1.00	.03	-.10	.16	.10	.02
PCM2M																	1.00	.50	-.28	.61	.57
DC3M																		1.00	-.06	.58	.35
CW3M																			1.00	.08	-.20
CTDV3M																				1.00	.55
PCM3M																					1.00

The following relationships are evident:

- The percentage of financial need is positively correlated with increased perceptions to the cost savings benefit of OER (r = .34). The percentage of financial need is also positively related to efficacious beliefs of ability to complete collaborative work tasks without help (r_{T1} = .60, r_{T2} = .46, r_{T3} = .34)

- The relationship between preference towards a textbook vs. preference towards OER is negative, indicating that increased preference for OER is related to a decreased preference for a textbook (r = -.34).

- Beliefs in the benefits of OER are positively related to satisfaction with utilizing OER/OEP within a course (r = .74), recommendation of OER (r = .60), preference for using OER (r = .51), and learning with OER (r = .47).

- The only significant relationship across efficacy variables and satisfaction towards OER appears with students' beliefs in their ability to complete tasks related to Programming and Computational Methods at the end of the semester (time 3: r = .354).

Figures 5 through 8 are used to further explore relationships between these variables and relationships across student characteristics. The majority of students in the study identified as White, with only 1 student identifying as Black/African American, 1 as Asian, 1 as Hispanic, and 3 students identified as international students. To protect the anonymity of these students' responses, race was recoded to indicate White students and non-White students. Noticeable trends include:

- (Figure 5). The perceptions of the cost benefits for OER are fairly spread out across individuals who did not need or did not apply for financial aid; whereas individuals with the highest financial aid need were clustered around a score of a great extent of cost benefits. There did not appear to be significant patterns in ratings across sex, race or grade.

- (Figure 6). The relationship between overall benefit of OER to race shows a pattern where those who are not White were more likely to rate the overall benefit of OER higher than those who were White. There did not appear to be significant patterns in financial aid need, sex or grade.

- (Figure 7). There did not appear to be significant patterns in financial aid need, sex, race, or grade received across positive learning with OER and OER satisfaction.

- (Figure 8). Students who received an A+ in the course reported efficacy of being able to complete all programming and computational method (PCM) tasks without help – but spread out across overall satisfaction scores. There did not appear to be patterns in PCM and overall OER satisfaction by financial aid need, sex, or race, although students who were not White tended to have higher satisfaction with OER scores than White students.

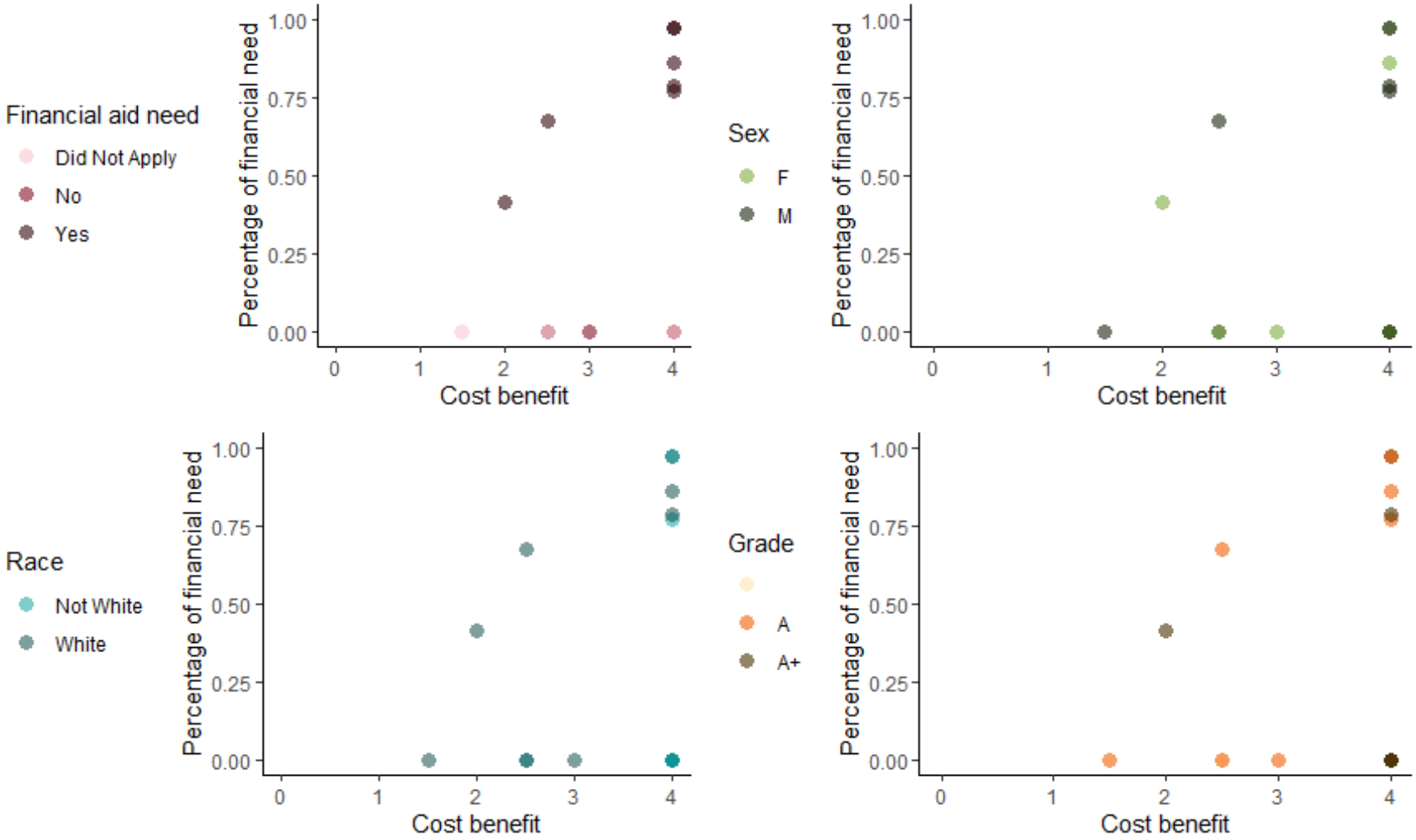


Figure 5. Relationship between the percentage of financial need and mean scores for cost benefits of OER categorized by groups: financial aid need, sex, aggregated race for white vs. non-white students, and course grade.

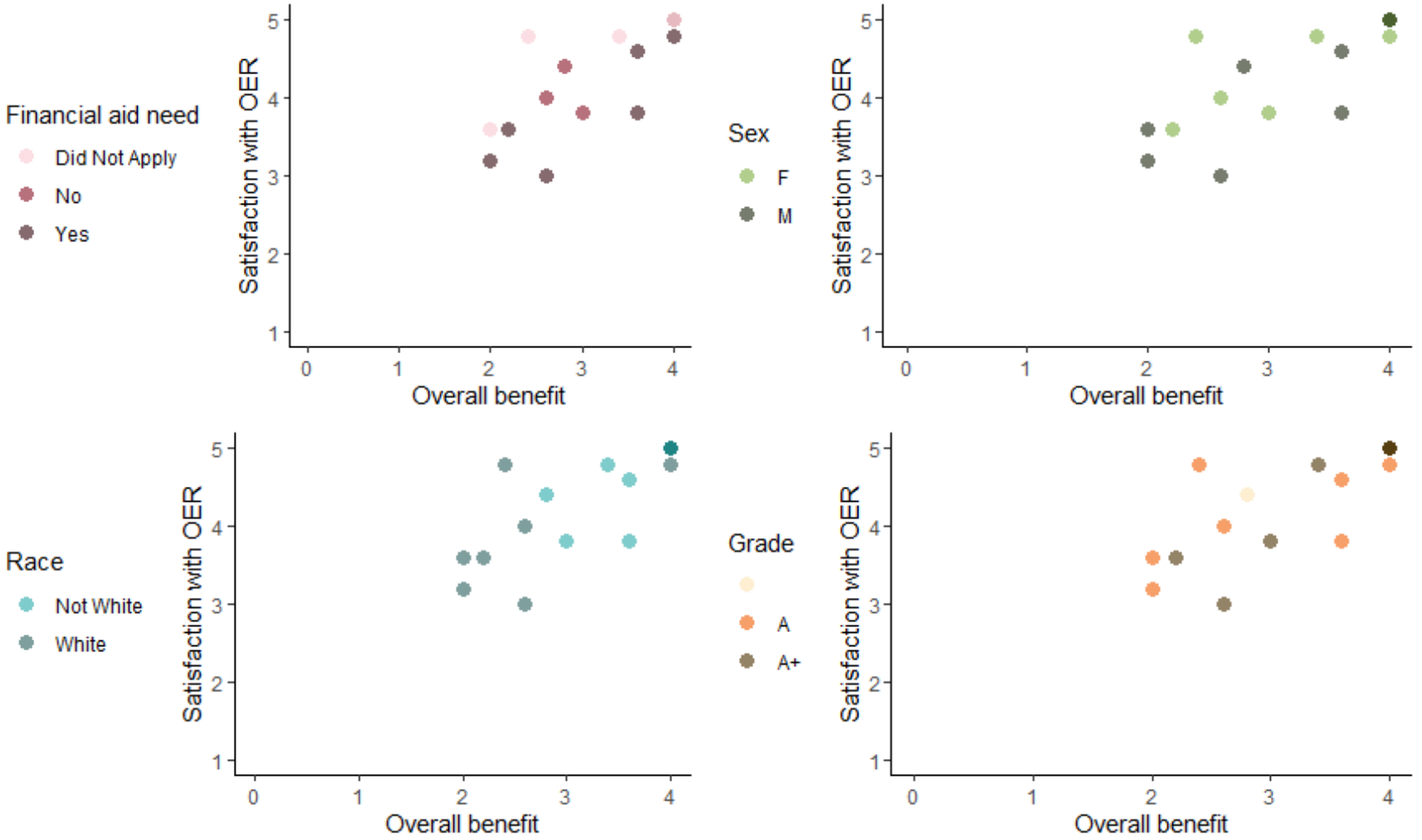


Figure 6. Relationship between the mean scores for overall OER benefit and satisfaction with OER categorized by groups: financial aid need, sex, aggregated race for white vs. non-white students, and course grade.

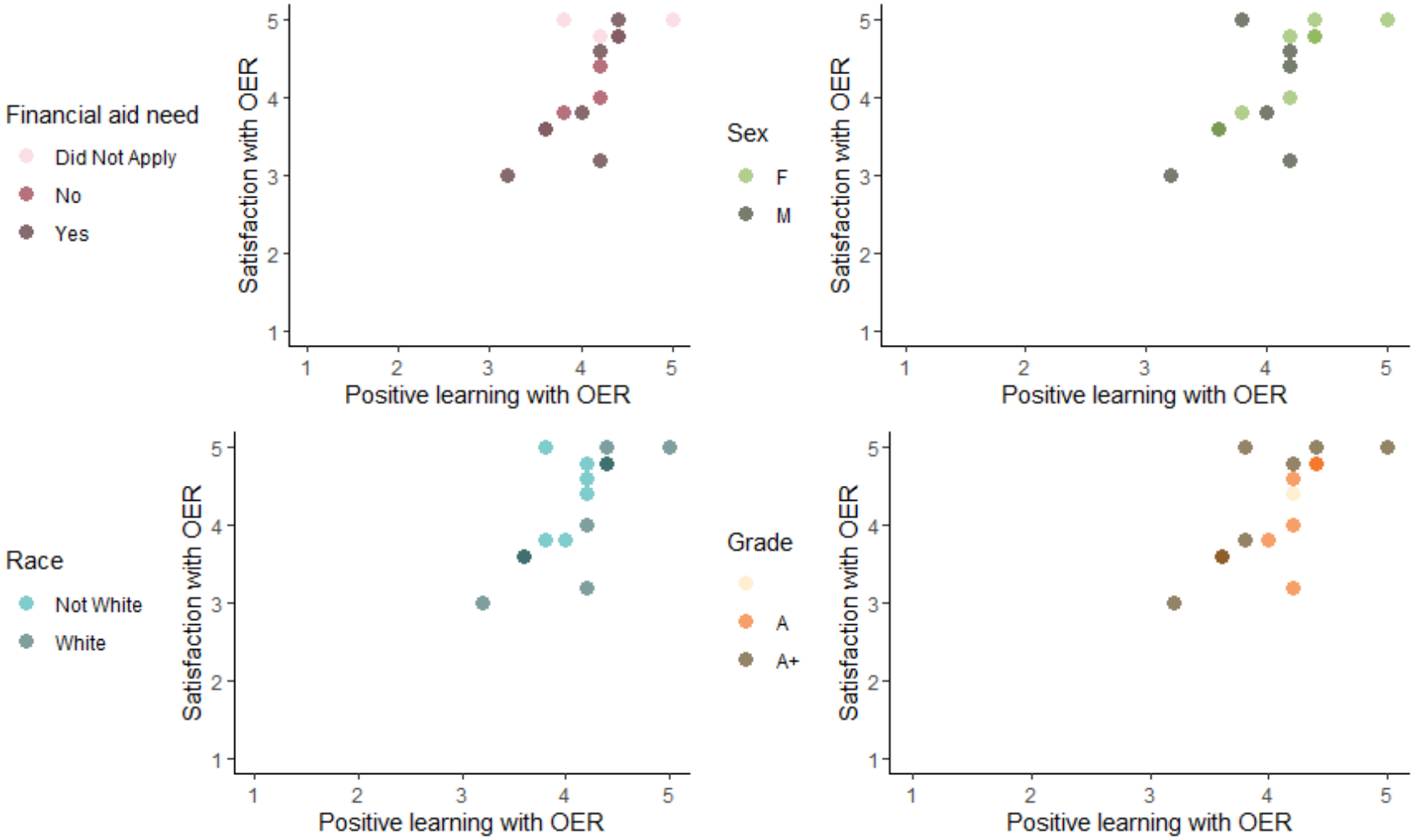


Figure 7. Relationship between the mean scores for positive learning with OER and satisfaction with OER categorized by groups: financial aid need, sex, aggregated race for white vs. non-white students, and course grade.

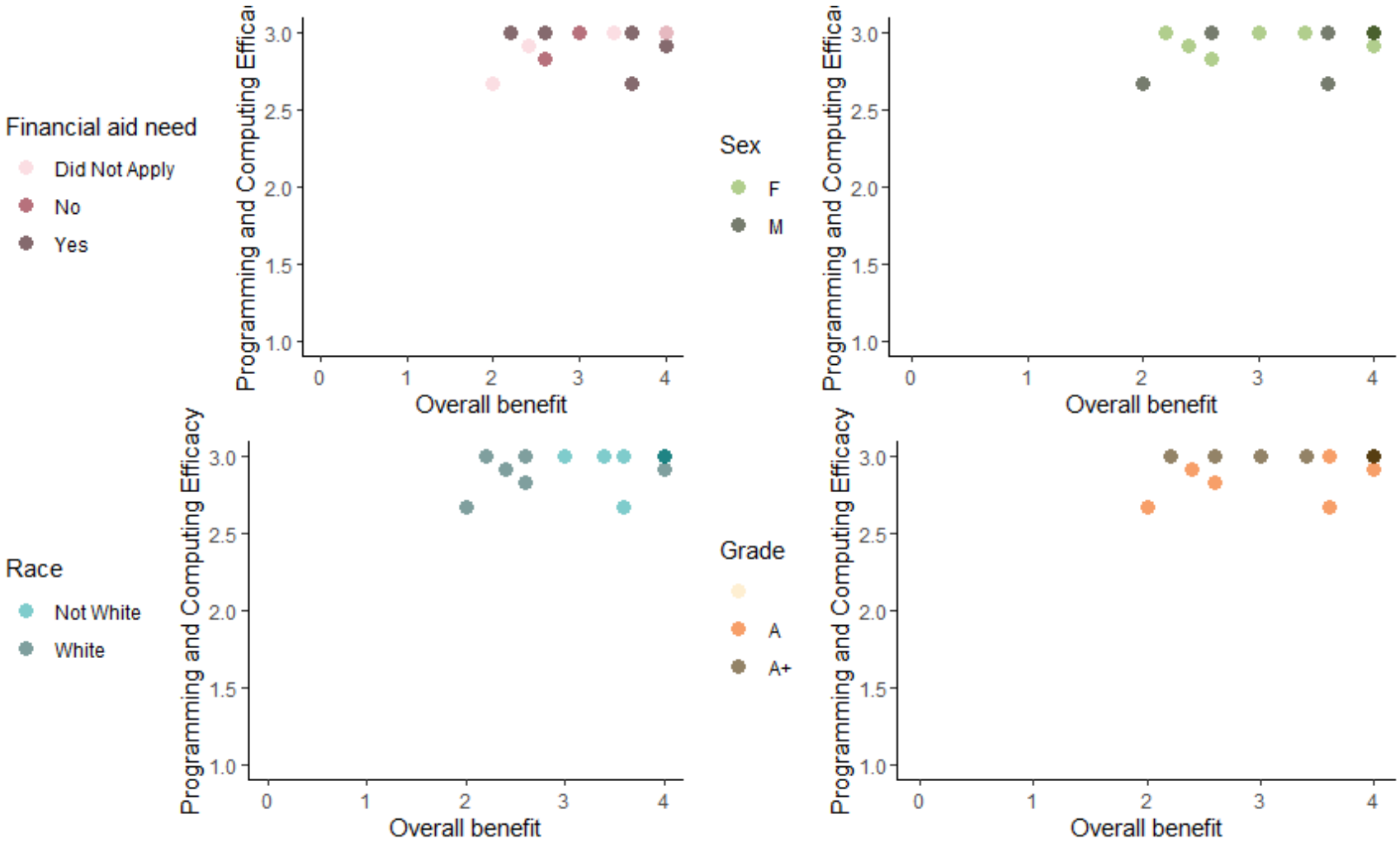


Figure 8. Relationship between the mean scores for positive learning with OER and programming and computing efficacy categorized by groups: financial aid need, sex, aggregated race for white vs. non-white students, and course grade.

APPENDICES

Appendix A: Instruments

Efficacy Portfolio (Can Do) Worksheet

	Can-do (DCS 304)	Week 1 Start without help	Week 1 Start with help	Week 1 Start my next target	Week 4 Midterm without help	Week 4 Midterm with help	Week 4 Midterm my next target	Final End without help	Final End with help	Final End my next target
Digital Citizenship										
1	Can define what bullshit is.	☐	☐	☐	☐	☐	☐	☐	☐	☐
2	Can utilize quick tools such as Fermi estimation and 5 Ws, to recognize BS.	☐	☐	☐	☐	☐	☐	☐	☐	☐
3	Can explain how BS is propagated and why BS is propagated.	☐	☐	☐	☐	☐	☐	☐	☐	☐
4	Can employ more time intensive techniques such as original source research and reproducing methods to recognize BS.	☐	☐	☐	☐	☐	☐	☐	☐	☐
5	Can leverage audience, context, and purpose recognizing and effectively refuting BS.	☐	☐	☐	☐	☐	☐	☐	☐	☐
6	Can effectively create a public facing digital portfolio/website to showcase your learning in a class for a peer audience.	☐	☐	☐	☐	☐	☐	☐	☐	☐
Collaborative Work and Play with Ideas										
7	Listen to others and be mindful of the space you take in full class and group.	☐	☐	☐	☐	☐	☐	☐	☐	☐
8	Respectfully contribute your thoughts and ideas to build a common group understanding (both in class and in online assignments).	☐	☐	☐	☐	☐	☐	☐	☐	☐
9	Communicate ideas clearly, using "I" or "we" when appropriate, and giving credit to classmates for shared ideas and understanding.	☐	☐	☐	☐	☐	☐	☐	☐	☐

10	Know, accept, value, trust, respect, care for and encourage your colleagues to be active and responsible members of the learning community.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
11	Clearly articulate roles and goals in group work, thinking about your own individual goals as well as the goals strengths of your colleagues.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
12	Can follow through with individual roles and tasks that are part of a larger group effort.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
13	Can pause and brainstorm ideas in response to question prompts and ideate a few ways to think about a problem, situation, and/or challenge.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
14	Can find joy from figuring out something on your own through creative trial and error and learning from past experience.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
15	Know when to seek help from your community when there is a challenge that could use additional viewpoints and/or experience.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
Critical, Quantitative Thinking and Data Visualization											
16	Can creatively play with various forms of data visualization to best express and communicate data.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
17	Can critically analyze data and visualizations of data.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
18	Can explain the principles by which a data visualization can be misused and used responsibly to communicate information about data for a particular context, audience, and purpose.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
19	Can create a data visualization which effectively and responsibly communicates information about data	☐	☐	☐	☐	☐	☐	☐	☐	☐	

	for a particular context, audience, and purpose.									
20	Can calculate a probability and a conditional probability.	☐	☐	☐	☐	☐	☐	☐	☐	☐
21	Can explain what a p-value is and what the limitations are.	☐	☐	☐	☐	☐	☐	☐	☐	☐
22	Can explain how chance might be responsible for a particular observation.	☐	☐	☐	☐	☐	☐	☐	☐	☐
23	Can distinguish when two variables are causally related or correlated and what the difference is.	☐	☐	☐	☐	☐	☐	☐	☐	☐
24	Can come up with alternative explanations for a particular observation.	☐	☐	☐	☐	☐	☐	☐	☐	☐
25	Can explain the benefits and limitations of linear models of data.	☐	☐	☐	☐	☐	☐	☐	☐	☐
26	Can use various representations of models to check the results of some modeling, arithmetic, reasoning, or computational process (effective implementation of a self-check process to avoid unintentional BS).	☐	☐	☐	☐	☐	☐	☐	☐	☐
Programming and Computational Methods										
27	Can explain the difference between the R programming language, Data Camp, and R Studio.	☐	☐	☐	☐	☐	☐	☐	☐	☐
28	Can organize your R Studio workspace into an effective layout for your goals and can utilize various areas, such as the command prompt, scripts, and workspace to troubleshoot code.	☐	☐	☐	☐	☐	☐	☐	☐	☐
29	Can perform numerical operations, such as add, subtract, multiply and divide, in R language.	☐	☐	☐	☐	☐	☐	☐	☐	☐
30	Can explain why and how we use a script to save commands in order to perform	☐	☐	☐	☐	☐	☐	☐	☐	☐

	repeated numerical operations and can implement in R.										
31	Can store/assign numerical data into a variable, vector, array, and or data frame with good naming practice and can retrieve this data as needed (in R).	☐	☐	☐	☐	☐	☐	☐	☐	☐	
32	Can recognize when a structure such as a function, loop, or data frame, is utilized (in R) as part of a programming implementation and why it is used.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
33	Can explain other variable types beyond numerical (such as strings and Boolean) and can recognize when and why they are implemented in the R language.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
34	Can recognize and modify as needed structure of data and the grammar of graphics in the R language to create an effective visualization.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
35	Can use professional practice in programming related to thoughtful and effective design processes such as writing verbal to-do steps, utilizing flow diagrams, pseudocode, the command window, and toy examples.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
36	Can creatively play with various approaches to a programming process.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
37	Can effectively communicate the process and results of a programming process, both within the context of the code itself through comments, as well as in written reports and verbal communication.	☐	☐	☐	☐	☐	☐	☐	☐	☐	
38	Can identify a problem, challenge and/or potential piece of BS in the wild that can be investigated/debunked using computational tools (in R), plan and execute the programming process, and interpret the results responsibly.	☐	☐	☐	☐	☐	☐	☐	☐	☐	

Student Survey for Open Education Practices

Your instructor is involved in numerous activities to support Open Educational Practices (for example the use of Figure of the Day; lectures and readings; R and RStudio open source software in your course). Her involvement has allowed her to understand impacts for faculty and instructors who utilize and adopt Open Education Resources within their teaching, but little information is available regarding students' attitudes and perceptions when participating in courses which focus on the inclusion of OER and Open software.

1) Please indicate your consent or non-consent to allow (or not allow) the following data to be used in the study.

☐ I give consent to use my "Can do" tab on your Self-Assessment data in the study.
☐ I do NOT give consent to use my "Can do" tab on your Self-Assessment data in the study.

☐ I give consent to use my grades in the Course in the study.
☐ I do NOT give consent to use my grades in the Course in the study.

☐ I give consent to use my institutional data (e.g., information the college has about my sex/gender, race/ethnicity, socioeconomic background) in the study.
☐ I do NOT give consent to use my institutional data (e.g., information the college has about my sex/gender, race/ethnicity, socioeconomic background) in the study.

☐ I will complete a survey about OEP and the data can be used in the study. Dr. Eaton will only receive a de-identified (e.g., all information to identify each student will be removed) file and an analyzed summary of students' responses to the survey. **[survey branch – if selected go to question 2].**
☐ I do NOT want to complete a survey about OEP, and therefore, data will not be used in the study. **[survey branch – if selected submit consent].**

Students' Attitudes Towards OEP Survey

2) Open Education resources can be defined as information and software that are free to download and utilize for educational purposes. The use of open education resources (OER) to support instruction continues to grow; however, it is uncertain how utilizing OER benefits students. For the DCS 105 course, please indicate the extent you feel each statement may have benefitted you.

	Not at all	A small extent	A moderate extent	A great extent	A very great extent
Using OER provided savings from no textbook cost.					
Using OER provided savings by using open software (datacamp – R, etc.)					
Using OER increased awareness for finding additional, trustworthy information about course material.					
The OER materials provided in the course supported learning outcomes.					
I expect to reuse or utilize learning materials from this course.					

3) As a student, what benefits (if any) do you feel resulted from completing a course which engaged open education practices?

_____

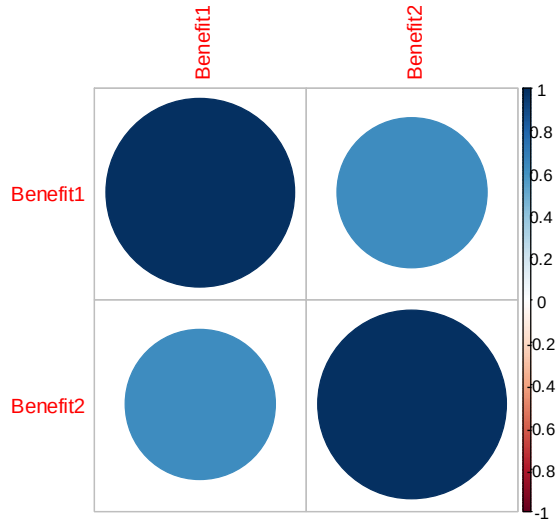
4) Indicate your level of agreement with each of the following statements.

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
I enjoy learning in an environment that incorporates OER.					
OER make me feel more engaged with my learning.					
If given a choice, I prefer learning using OER.					
OER directly improve the quality of my learning experience in this course.					
There is a match between the OER content and specific learning objectives of this course.					
If given a choice, I prefer learning using a textbook.					
I think this course is of less value to me because anyone can access the materials.					
OER are not as good as purchased textbooks.					
Textbooks help me understand topics better than OER.					
I believe I can learn more through OER than through a textbook					
OER help me understand topics better than textbooks.					
OER does not offer any advantages to me.					
I can intelligently critique the OER used in this course.					
I have changed my attitudes about this course subject matter as a result of this course.					
I feel more self-reliant as a result of this course.					
I feel I am a more sophisticated thinker as a result of this course.					
I would like to take more courses that use OER.					
I would recommend a course that uses OER to others.					
Overall the learning experience in this course was positive.					
Overall the quality of the OER content of this course was excellent.					

Appendix B: Benefit Scale

Label	Item	Scale
Benefit1	Using OER provided savings from no textbook cost.	0 – Not at all 1 – A small extent 2 – A moderate extent 3 – A great extent 4 – A very great extent
Benefit2	Using OER provided savings by using open software (datacamp – R, etc.)	
Benefit3	Using OER increased awareness for finding additional, trustworthy information about course material.	
Benefit4	The OER materials provided in the course supported learning outcomes.	
Benefit5	I expect to reuse or utilize learning materials from this course.	

OER Cost Benefit

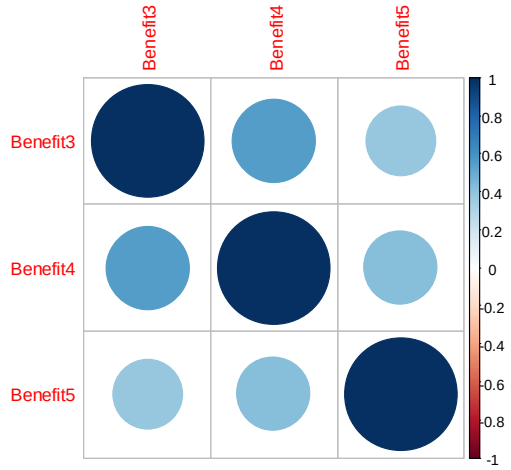


	Benefit1	Benefit2
Benefit1	1	.63
Benefit2	.63	1

Correlation matrix

```
  raw_alpha std.alpha G6(smc) average_r S/N  ase mean  sd median_r
      0.65      0.77    0.63      0.63 3.4 0.12  3.3 0.9     0.63

 lower alpha upper     95% confidence boundaries
0.42 0.65 0.89

 Reliability if an item is dropped:
         raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Benefit1       1.3      0.63    0.39      0.63 1.7       NA     0  0.63
Benefit2       0.3      0.63    0.39      0.63 1.7       NA     0  0.63

 Item statistics
          n raw.r std.r r.cor r.drop mean   sd
Benefit1 15  0.96   0.9  0.71   0.63  3.1 1.33
Benefit2 15  0.82   0.9  0.71   0.63  3.6 0.63
```

OER Learning Benefit

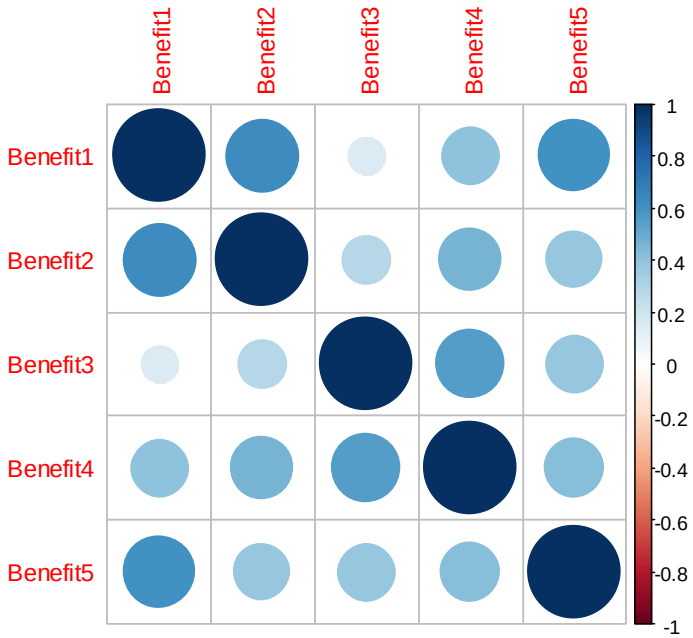


	Benefit3	Benefit4	Benefit5
Benefit3	1	.55	.39
Benefit4		1	.42
Benefit5			1

Correlation matrix

```
 raw_alpha std.alpha G6(smc) average_r S/N  ase mean   sd median_r
      0.67      0.71    0.63      0.46 2.5 0.14  2.9 0.84     0.42

 lower alpha upper     95% confidence boundaries
0.41 0.67 0.94

 Reliability if an item is dropped:
         raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Benefit3      0.53      0.59    0.42      0.42 1.5     0.20    NA  0.42
Benefit4      0.55      0.56    0.39      0.39 1.3     0.22    NA  0.39
Benefit5      0.69      0.71    0.55      0.55 2.5     0.14    NA  0.55

 Item statistics
          n raw.r std.r r.cor r.drop mean   sd
Benefit3 15  0.79  0.81  0.67   0.52  2.9 1.03
Benefit4 15  0.76  0.83  0.70   0.57  3.2 0.77
Benefit5 15  0.83  0.76  0.54   0.46  2.6 1.35
```

OER Overall Benefit



	Benefit1	Benefit2	Benefit3	Benefit4	Benefit5
Benefit1	1	.63	.16	.40	.61
Benefit2		1	.28	.47	.38
Benefit3			1	.55	.39
Benefit4				1	.42
Benefit5					1

Correlation matrix

```
  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
       0.76      0.79     0.8      0.43 3.8 0.088  3.1 0.76     0.41

 lower alpha upper     95% confidence boundaries
0.59 0.76 0.93

 Reliability if an item is dropped:
         raw_alpha std.alpha G6(smc) average_r S/N alpha se  var.r med.r
Benefit1      0.70      0.74    0.70      0.42 2.9    0.112 0.0081  0.41
Benefit2      0.73      0.75    0.74      0.42 2.9    0.107 0.0247  0.41
Benefit3      0.76      0.79    0.77      0.49 3.8    0.083 0.0114  0.44
Benefit4      0.71      0.73    0.74      0.41 2.8    0.107 0.0333  0.39
Benefit5      0.68      0.74    0.73      0.42 2.8    0.129 0.0299  0.43

 Item statistics
          n raw.r std.r r.cor r.drop mean   sd
Benefit1 15  0.79  0.76  0.72   0.59  3.1 1.33
Benefit2 15  0.69  0.75  0.67   0.59  3.6 0.63
Benefit3 15  0.62  0.65  0.53   0.41  2.9 1.03
Benefit4 15  0.72  0.77  0.69   0.60  3.2 0.77
Benefit5 15  0.82  0.76  0.69   0.64  2.6 1.35
```

Appendix C: Agreement Scale

Satisfaction with OER (Items 1, 2, 3, 4, 5)

Preference towards Textbook (Items 6, 7, 8, 9, 12)

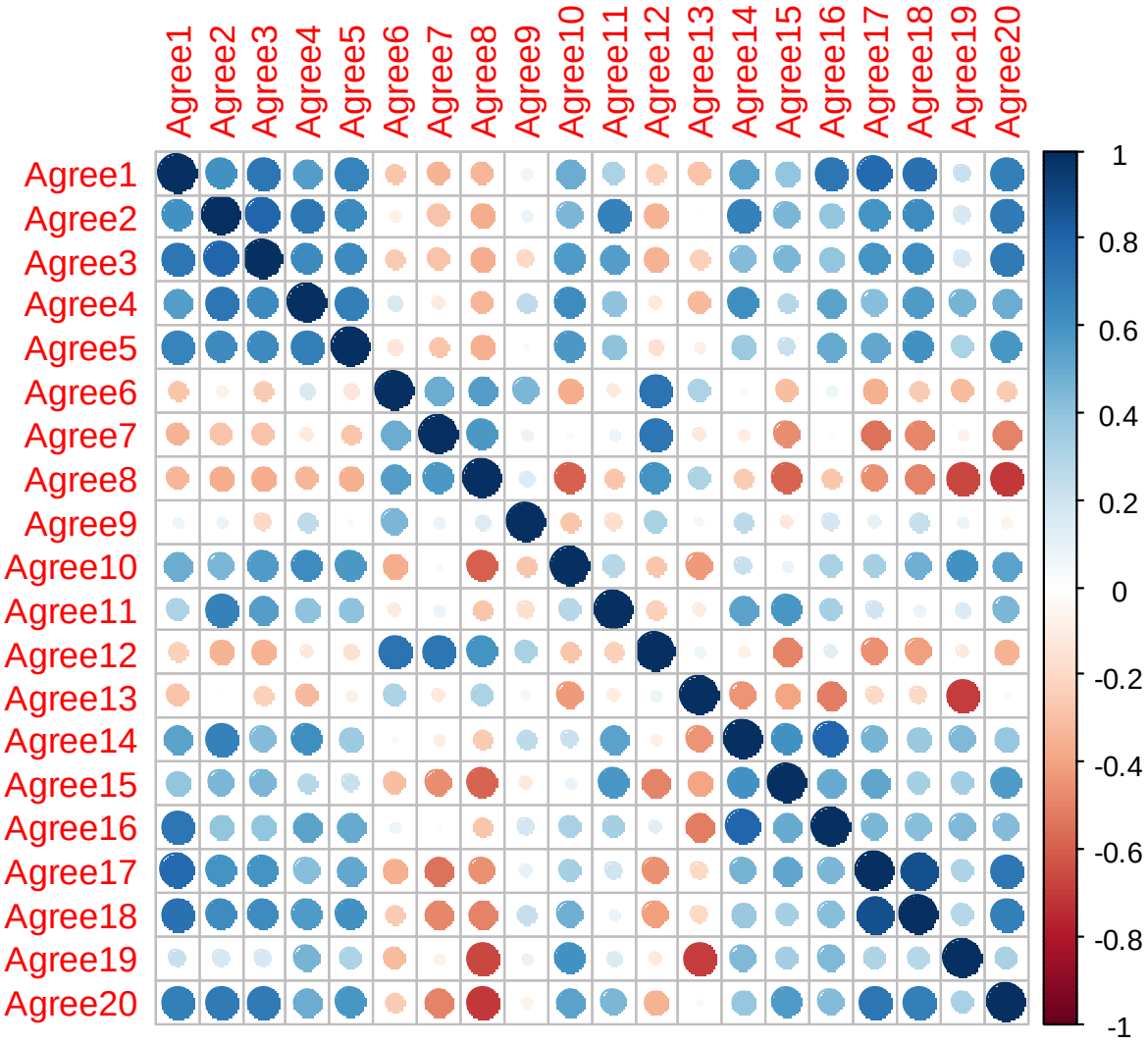
Preference towards OER (Items 10, 11)

Recommend OER (Items 17, 18)

Course Learning (Items 13, 14, 15, 16, 19, 20)

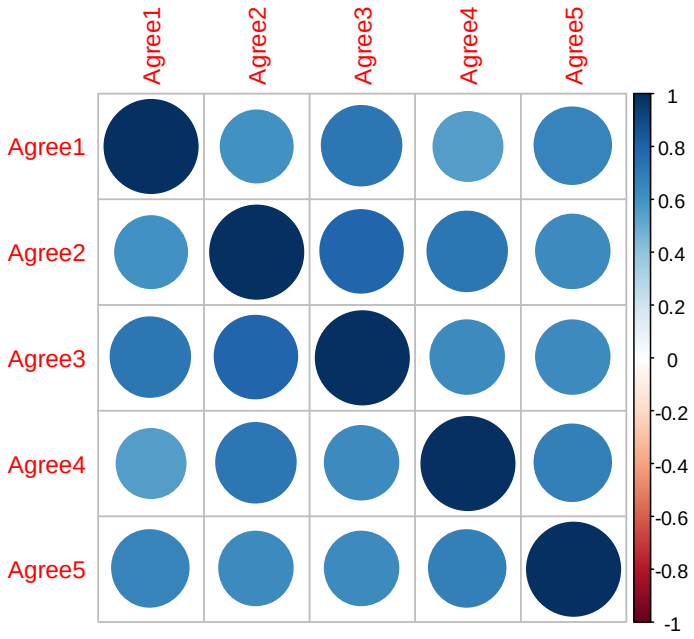
Label	Item	Scale
Agree1	I enjoy learning in an environment that incorporates OER.	1 – Strongly disagree 2 – Disagree 3 – Neutral 4 – Agree 5 – Strongly agree
Agree2	OER make me feel more engaged with my learning.	
Agree3	If given a choice, I prefer learning using OER.	
Agree4	OER directly improve the quality of my learning experience in this course.	
Agree5	There is a match between the OER content and specific learning objectives of this course.	
Agree6	If given a choice, I prefer learning using a textbook.	
Agree7	I think this course is of less value to me because anyone can access the materials.	
Agree8	OER are not as good as purchased textbooks.	
Agree9	Textbooks help me understand topics better than OER.	
Agree10	I believe I can learn more through OER than through a textbook.	
Agree11	OER help me understand topics better than textbooks.	
Agree12	OER does not offer any advantages to me.	
Agree13	I can intelligently critique the OER used in this course.	
Agree14	I have changed my attitudes about this course subject matter as a result of this course.	
Agree15	I feel more self-reliant as a result of this course.	
Agree16	I feel I am a more sophisticated thinker as a result of this course.	
Agree17	I would like to take more courses that use OER.	
Agree18	I would recommend a course that uses OER to others.	
Agree19	Overall, the learning experience in this course was positive.	
Agree20	Overall, the quality of the OER content of this course was excellent.	

Note. Items 7, 8, and 13 was removed from analyses due to a negative correlations with other scales. Reverse coding did not help.


Agree1
Agree2
Agree3
Agree4
Agree5
Agree6
Agree7
Agree8
Agree9
Agree10
Agree11
Agree12
Agree13
Agree14
Agree15
Agree16
Agree17
Agree18
Agree19
Agree20
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1

```
Reliability analysis
Call: alpha(x = agree)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.77       0.8    0.88      0.16 3.9 0.084  3.5 0.33     0.23

 lower alpha upper     95% confidence boundaries
0.6 0.77 0.93

 Reliability if an item is dropped:
        raw_alpha std.alpha G6(smc) average_r S/N var.r med.r
Agree1       0.73      0.77    0.89      0.15 3.3  0.16  0.19
Agree2       0.72      0.76    0.87      0.14 3.2  0.16  0.22
Agree3       0.74      0.77    0.94      0.15 3.3  0.16  0.22
Agree4       0.72      0.76    0.89      0.14 3.2  0.17  0.19
Agree5       0.74      0.77    0.91      0.15 3.3  0.17  0.19
Agree6       0.78      0.81    0.90      0.18 4.2  0.17  0.29
Agree7       0.80      0.82    0.91      0.19 4.5  0.16  0.30
Agree8       0.79      0.83    0.91      0.20 4.9  0.15  0.29
Agree9       0.77      0.80    0.92      0.17 4.0  0.18  0.31
Agree10      0.75      0.78    0.89      0.16 3.6  0.17  0.22
Agree11      0.75      0.78    0.89      0.16 3.6  0.17  0.23
Agree12      0.78      0.81    0.90      0.19 4.4  0.16  0.29
Agree13      0.80      0.83    0.92      0.20 4.8  0.16  0.32
Agree14      0.73      0.77    0.87      0.15 3.3  0.17  0.19
Agree15      0.76      0.79    0.89      0.16 3.7  0.16  0.22
Agree16      0.74      0.77    0.88      0.15 3.3  0.17  0.19
Agree17      0.75      0.77    0.89      0.15 3.4  0.16  0.22
Agree18      0.74      0.77    0.89      0.15 3.4  0.16  0.19
Agree19      0.76      0.79    0.90      0.17 3.8  0.17  0.24
Agree20      0.75      0.77    0.90      0.15 3.4  0.16  0.19
```

Satisfaction with OER

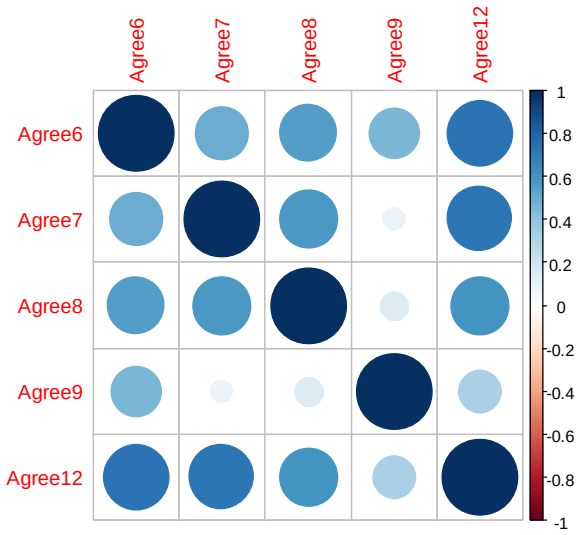


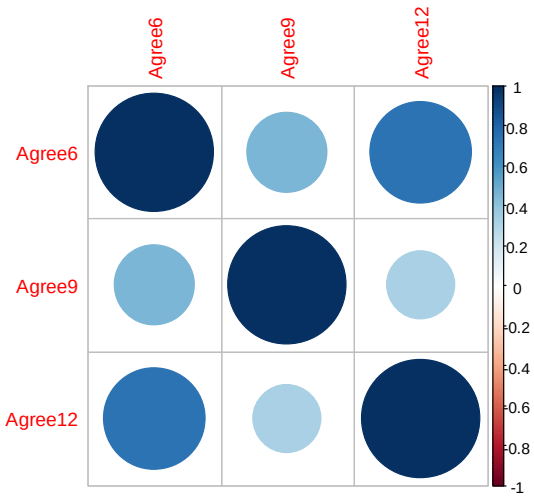
	Agree1	Agree2	Agree3	Agree4	Agree5
Agree1	1	.60	.72	.55	.67
Agree2		1	.79	.72	.63
Agree3			1	.63	.63
Agree4				1	.68
Agree5					1

Correlation matrix

```
   raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
        0.91      0.91     0.9      0.66 9.9 0.037  4.2 0.69     0.65

 lower alpha upper     95% confidence boundaries
0.83 0.91 0.98

 Reliability if an item is dropped:
       raw_alpha std.alpha G6(smc) average_r S/N alpha se  var.r med.r
Agree1      0.89      0.90    0.88      0.68 8.6    0.043 0.0044  0.66
Agree2      0.88      0.88    0.86      0.65 7.3    0.051 0.0034  0.65
Agree3      0.88      0.88    0.85      0.64 7.2    0.050 0.0038  0.65
Agree4      0.89      0.89    0.88      0.68 8.3    0.044 0.0050  0.65
Agree5      0.89      0.89    0.88      0.67 8.1    0.045 0.0082  0.68

 Item statistics
        n raw.r std.r r.cor r.drop mean   sd
Agree1 15  0.82  0.83  0.77   0.72  4.4 0.74
Agree2 15  0.88  0.88  0.85   0.81  4.1 0.83
Agree3 15  0.88  0.88  0.86   0.81  4.1 0.83
Agree4 15  0.85  0.84  0.79   0.74  4.1 0.92
Agree5 15  0.84  0.85  0.79   0.75  4.3 0.72
```

Textbook Preference



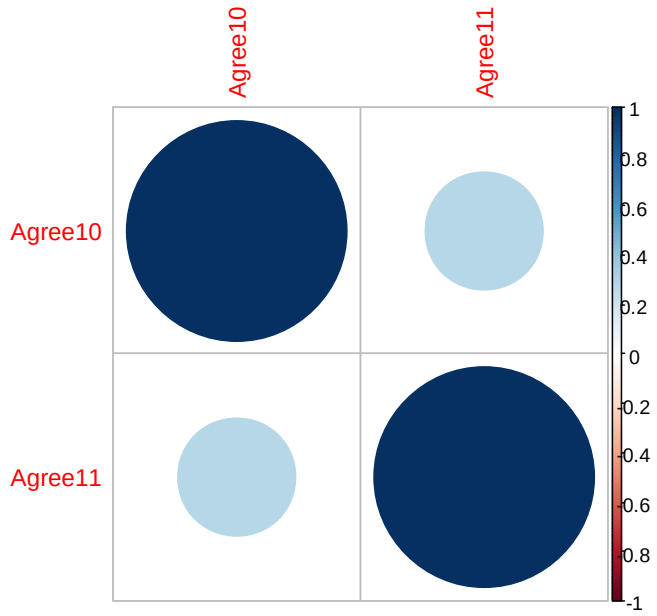


	Agree6	Agree7	Agree8	Agree9	Agree12
Agree6	1	.49	.56	.45	.74
Agree7		1	.58	.09	.73
Agree8			1	.14	.59
Agree9				1	.33
Agree12					1

Correlation matrix

```
  raw_alpha std.alpha G6(smc) average_r S/N  ase mean   sd median_r
      0.75      0.75    0.72      0.51 3.1 0.11  2.1 0.74     0.45

 lower alpha upper     95% confidence boundaries
0.55 0.75 0.96

 Reliability if an item is dropped:
       raw_alpha std.alpha G6(smc) average_r  S/N alpha se var.r med.r
Agree6      0.50      0.50    0.33      0.33 0.98    0.252    NA  0.33
Agree9      0.84      0.85    0.74      0.74 5.58    0.077    NA  0.74
Agree12     0.62      0.62    0.45      0.45 1.65    0.189    NA  0.45

 Item statistics
         n raw.r std.r r.cor r.drop mean   sd
Agree6  15  0.90  0.89  0.85   0.72  2.5 0.99
Agree9  15  0.72  0.73  0.47   0.43  2.1 0.88
Agree12 15  0.83  0.84  0.77   0.64  1.7 0.82
```

OER Preference

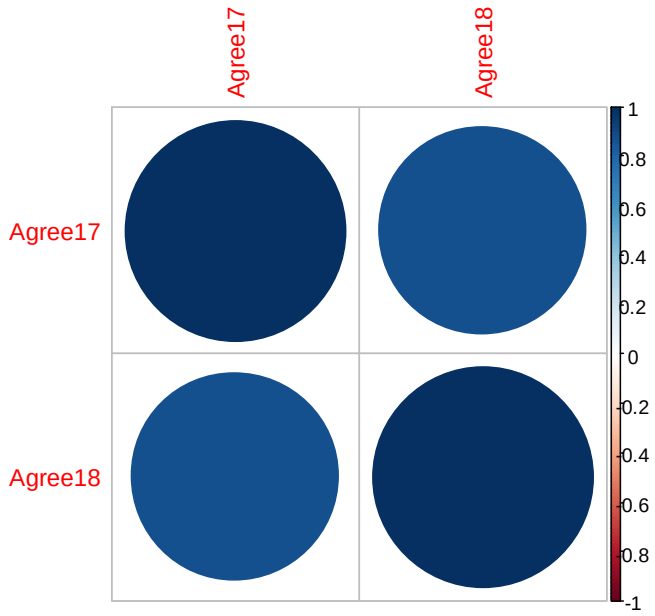


	Agree10	Agree11
Agree10	1	.29
Agree11		1

Correlation matrix

```
  raw_alpha std.alpha G6(smc) average_r S/N  ase mean   sd median_r
      0.45      0.45    0.29      0.29 0.8 0.28  3.6 0.59     0.29

 lower alpha upper     95% confidence boundaries
-0.1 0.45 0.99

 Reliability if an item is dropped:
        raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Agree10      0.29      0.29   0.082      0.29 0.4       NA     0  0.29
Agree11      0.28      0.29   0.082      0.29 0.4       NA     0  0.29

 Item statistics
         n raw.r std.r r.cor r.drop mean   sd
Agree10 15   0.8   0.8  0.43   0.29  3.5 0.74
Agree11 15   0.8   0.8  0.43   0.29  3.6 0.74
```

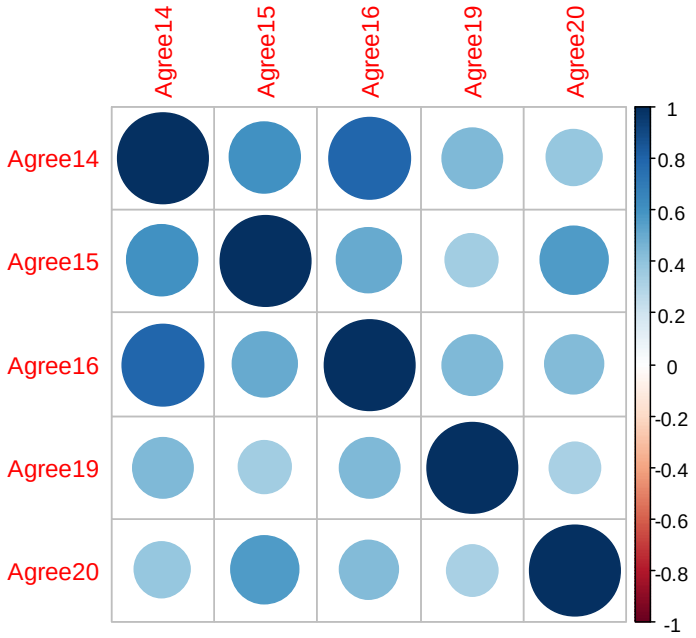
Recommend OER



	Agree17	Agree18
Agree17	1	.88
Agree18	.88	1

Correlation matrix

```
Reliability analysis
Call: alpha(x = CB[, c(31, 32)])

  raw_alpha std.alpha G6(smc) average_r S/N  ase mean   sd median_r
      0.45      0.45    0.29      0.29 0.8 0.28  3.6 0.59     0.29

 lower alpha upper     95% confidence boundaries
-0.1 0.45 0.99

 Reliability if an item is dropped:
        raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
Agree10      0.29      0.29   0.082      0.29 0.4       NA     0  0.29
Agree11      0.28      0.29   0.082      0.29 0.4       NA     0  0.29

 Item statistics
         n raw.r std.r r.cor r.drop mean   sd
Agree10 15   0.8   0.8  0.43   0.29  3.5 0.74
Agree11 15   0.8   0.8  0.43   0.29  3.6 0.74
```



	Agree14	Agree15	Agree16	Agree19	Agree20
Agree14	1	.61	.79	.45	.39
Agree15		1	.51	.34	.57
Agree16			1	.44	.43
Agree19				1	.33
Agree20					1

Correlation matrix

```
  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.82      0.83    0.83      0.49 4.7 0.067  4.1 0.43     0.44

 lower alpha upper     95% confidence boundaries
0.69 0.82 0.95

 Reliability if an item is dropped:
        raw_alpha std.alpha G6(smc) average_r S/N alpha se  var.r med.r
Agree14      0.75      0.76    0.71      0.44 3.1    0.100 0.0088  0.44
Agree15      0.77      0.78    0.77      0.47 3.6    0.088 0.0265  0.44
Agree16      0.76      0.76    0.73      0.45 3.2    0.093 0.0140  0.42
Agree19      0.82      0.83    0.83      0.55 4.9    0.070 0.0207  0.54
Agree20      0.81      0.81    0.80      0.52 4.4    0.073 0.0249  0.48

 Item statistics
         n raw.r std.r r.cor r.drop mean   sd
Agree14 15  0.87  0.84  0.84   0.73  3.7 0.72
Agree15 15  0.80  0.79  0.73   0.66  3.9 0.59
Agree16 15  0.82  0.83  0.81   0.73  3.9 0.46
Agree19 15  0.65  0.67  0.52   0.48  4.5 0.52
Agree20 15  0.69  0.71  0.60   0.53  4.4 0.51
```

Appendix D: Efficacy Scales

Digital Citizenship

Mean ratings of 'digital citizenship' goals across time (where 1 = my next target, 2 = with help, and 3 = without help) and number of students indicating they can complete the goal without help across time

		DC Mean Ratings			DC count without help		
Item	Digital Citizenship (DC) Goals	T1	T2	T3	T1	T2	T3
DC1	Can define what bullshit is.	2.38	3.00	3.00	8	16	14
DC2	Can utilize quick tools such as Fermi estimation and 5 Ws, to recognize BS.	1.38	2.33	2.79	0	8	11
DC3	Can explain how BS is propagated and why BS is propagated.	1.63	2.73	2.93	0	12	13
DC4	Can employ more time intensive techniques such as original source research and reproducing methods to recognize BS.	1.75	2.40	2.93	3	8	13
DC5	Can leverage audience, context, and purpose recognizing and effectively refuting BS.	1.75	2.56	3.00	3	10	14
DC6	Can effectively create a public facing digital portfolio/website to showcase your learning in a class for a peer audience.	1.50	1.88	3.00	1	3	14

Pictorial image of DC mean ratings and counts without help for each item.

	DC Mean Ratings				DC count without help			
Item	T1	T2	T3	Sparkline	T1	T2	T3	Counts
DC1	2.38	3.00	3.00		8	16	14	
DC2	1.38	2.33	2.79		0	8	11	
DC3	1.63	2.73	2.93		0	12	13	
DC4	1.75	2.40	2.93		3	8	13	
DC5	1.75	2.56	3.00		3	10	14	
DC6	1.50	1.88	3.00		1	3	14	

Collaborative Work and Play with Ideas

Mean ratings of 'collaborative work and play with ideas' goal across time (where 1 = my next target, 2 = with help, and 3 = without help) and number of students indicating they can complete the goal without help across time

Item	Collaborative Work and Play with Ideas (CW) Goals	CW Mean Ratings			CW Count Without Help		
		T1	T2	T3	T1	T2	T3
CW1	Listen to others and be mindful of the space you take in full class and group.	3.00	3.00	3.00	16	16	14
CW2	Respectfully contribute your thoughts and ideas to build a common group understanding (both in class and in online assignments).	2.88	3.00	3.00	14	16	14
CW3	Communicate ideas clearly, using "I" or "we" when appropriate, and giving credit to classmates for shared ideas and understanding.	2.81	2.88	3.00	13	14	14
CW4	Know, accept, value, trust, respect, care for and encourage your colleagues to be active and responsible members of the learning community.	3.00	3.00	3.00	16	16	14
CW5	Clearly articulate roles and goals in group work, thinking about your own individual goals as well as the goals strengths of your colleagues.	2.81	2.81	2.86	14	13	12
CW6	Can follow through with individual roles and tasks that are part of a larger group effort.	2.94	3.00	3.00	15	16	14
CW7	Can pause and brainstorm ideas in response to question prompts and ideate a few ways to think about a problem, situation, and/or challenge.	2.75	2.94	2.93	12	15	13
CW8	Can find joy from figuring out something on your own through creative trial and error and learning from past experience.	2.88	2.94	3.00	15	15	14
CW9	Know when to seek help from your community when there is a challenge that could use additional viewpoints and/or experience.	2.69	2.81	2.93	11	13	13

Pictorial image of CW mean ratings and counts without help for each item.

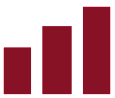
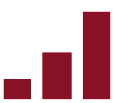
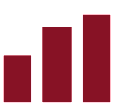
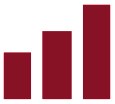
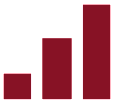
	CW Mean Ratings				CW Count Without Help			
Item	T1	T2	T3	Sparkline	T1	T2	T3	Counts
CW1	3.00	3.00	3.00		16	16	14	
CW2	2.88	3.00	3.00		14	16	14	
CW3	2.81	2.88	3.00		13	14	14	
CW4	3.00	3.00	3.00		16	16	14	
CW5	2.81	2.81	2.86		14	13	12	
CW6	2.94	3.00	3.00		15	16	14	
CW7	2.75	2.94	2.93		12	15	13	
CW8	2.88	2.94	3.00		15	15	14	
CW9	2.69	2.81	2.93		11	13	13	

Critical, Quantitative Thinking and Data Visualization

Mean ratings of 'critical, quantitative thinking and data visualization' goals across time (where 1 = my next target, 2 = with help, and 3 = without help) and number of students indicating they can complete the goal without help across time

Item	Critical, Quantitative Thinking and Data Visualization (CTDV) Goals	CTDV Mean Ratings			CTDV Count Without Help		
		T1	T2	T3	T1	T2	T3
CTDV1	Can creatively play with various forms of data visualization to best express and communicate data.	2.06	2.50	2.93	5	8	13
CTDV2	Can critically analyze data and visualizations of data.	2.31	2.56	2.93	7	10	13
CTDV3	Can explain the principles by which a data visualization can be misused and used responsibly to communicate information about data for a particular context, audience, and purpose.	1.75	2.31	3.00	2	6	14
CTDV4	Can create a data visualization which effectively and responsibly communicates information about data for a particular context, audience, and purpose.	2.00	2.44	2.93	3	7	13
CTDV5	Can calculate a probability and a conditional probability.	2.06	2.44	2.79	5	7	11
CTDV6	Can explain what a p-value is and what the limitations are.	2.06	2.69	2.93	7	11	13
CTDV7	Can explain how chance might be responsible for a particular observation.	1.81	2.44	3.00	3	9	14
CTDV8	Can distinguish when two variables are causally related or correlated and what the difference is.	2.19	2.81	3.00	6	13	14
CTDV9	Can come up with alternative explanations for a particular observation.	2.19	2.50	3.00	7	10	14
CTDV10	Can explain the benefits and limitations of linear models of data.	1.88	2.44	3.00	4	9	14
CTDV11	Can use various representations of models to check the results of some modeling, arithmetic, reasoning, or computational process (effective implementation of a self-check process to avoid unintentional BS).	1.56	2.25	2.93	1	6	13

Pictorial image of CTDV mean ratings and counts without help for each item.

	CTDV Mean Ratings				CTDV Count Without Help			
Item	T1	T2	T3	Sparkline	T1	T2	T3	Counts
CTDV1	2.06	2.50	2.93		5	8	13	
CTDV2	2.31	2.56	2.93		7	10	13	
CTDV3	1.75	2.31	3.00		2	6	14	
CTDV4	2.00	2.44	2.93		3	7	13	
CTDV5	2.06	2.44	2.79		5	7	11	
CTDV6	2.06	2.69	2.93		7	11	13	
CTDV7	1.81	2.44	3.00		3	9	14	
CTDV8	2.19	2.81	3.00		6	13	14	
CTDV9	2.19	2.50	3.00		7	10	14	
CTDV10	1.88	2.44	3.00		4	9	14	
CTDV11	1.56	2.25	2.93		1	6	13	

Programming and Computational Methods

Mean ratings of 'programming and computational methods' goals across time (where 1 = my next target, 2 = with help, and 3 = without help) and number of students indicating they can complete the goal without help across time

Item	Programming and Computational Methods (PCM) Goals	PCM Mean Ratings			PCM Count Without Help		
		T1	T2	T3	T1	T2	T3
PCM1	Can explain the difference between the R programming language, Data Camp, and R Studio.	1.44	2.88	2.93	0	14	13
PCM2	Can organize your R Studio workspace into an effective layout for your goals and can utilize various areas, such as the command prompt, scripts, and workspace to troubleshoot code.	1.19	2.47	2.86	0	7	12
PCM3	Can perform numerical operations, such as add, subtract, multiply and divide, in R language.	2.13	2.94	3.00	6	15	14
PCM4	Can explain why and how we use a script to save commands in order to perform repeated numerical operations and can implement in R.	1.38	2.69	2.86	1	11	12
PCM5	Can store/assign numerical data into a variable, vector, array, and or data frame with good naming practice and can retrieve this data as needed (in R).	1.56	2.69	2.93	1	11	13
PCM6	Can recognize when a structure such as a function, loop, or data frame, is utilized (in R) as part of a programming implementation and why it is used.	1.44	2.50	2.86	0	8	12
PCM7	Can explain other variable types beyond numerical (such as strings and Boolean) and can recognize when and why they are implemented in the R language.	1.44	2.56	2.86	2	9	12
PCM8	Can recognize and modify as needed structure of data and the grammar of graphics in the R language to create an effective visualization.	1.19	2.13	2.86	0	3	12
PCM9	Can use professional practice in programming related to thoughtful and effective design processes such as writing verbal to-do steps, utilizing flow diagrams, pseudocode, the command window, and toy examples.	1.13	1.75	2.86	0	0	12
PCM10	Can creatively play with various approaches to a programming process.	1.47	2.13	3.00	2	4	13
PCM11	Can effectively communicate the process and results of a programming process, both within the context of the code itself through comments, as well as in written reports and verbal communication.	1.20	2.25	3.00	0	5	14
PCM12	Can identify a problem, challenge and/or potential piece of BS in the wild that can be investigated/debunked using computational tools (in R), plan and execute the programming process, and interpret the results responsibly.	1.31	1.81	2.93	0	1	13

Pictorial image of PCM mean ratings and counts without help for each item.

	PCM Mean Ratings				PCM Count Without Help			
Item	T1	T2	T3	Sparkline	T1	T2	T3	Counts
PCM1	1.44	2.88	2.93		0	14	13	
PCM2	1.19	2.47	2.86		0	7	12	
PCM3	2.13	2.94	3.00		6	15	14	
PCM4	1.38	2.69	2.86		1	11	12	
PCM5	1.56	2.69	2.93		1	11	13	
PCM6	1.44	2.50	2.86		0	8	12	
PCM7	1.44	2.56	2.86		2	9	12	
PCM8	1.19	2.13	2.86		0	3	12	
PCM9	1.13	1.75	2.86		0	0	12	
PCM10	1.47	2.13	3.00		2	4	13	
PCM11	1.20	2.25	3.00		0	5	14	
PCM12	1.31	1.81	2.93		0	1	13	

Appendix E: Description of Variable Names

Variable Name	Description	
%Need (PercentNeed)	Percentage computed as the amount of financial need student had divided by cost of attendance at institution. Values range from 0 to 1.00	
CostBen	Average response across 2 survey items related to OER cost saving benefits. Values range from 0 to 4, where 0 indicates no benefit or very little and 4 represents a great extent.	
LearnBen	Average response across 3 survey items related to OER benefits to learning. Values range from 0 to 4, where 0 indicates no benefit or very little and 4 represents a great extent.	
OverallBen	Overall scale that averages 5 survey items (CostBen and LearnBen) related to overall OER benefits. Values range from 0 to 4, where 0 indicates no benefit or very little and 4 represents a great extent.	
SatOER	Average response across 5 survey items related to satisfaction or favorable attitudes towards OER. Values range from 1 to 5, where 1 represents less agreement and 5 represents strong, favorable agreement.	
TextPref	Average response across 3 survey items related to preference for using a textbook. Values range from 1 to 5, where 1 represents less agreement and 5 represents strong, favorable agreement.	
OERPref	Average response across 3 survey items related to preference for using OER. Values range from 1 to 5, where 1 represents less agreement and 5 represents strong, favorable agreement.	
RecOER	Average response across 2 survey items related to recommending OER. Values range from 1 to 5, where 1 represents less agreement and 5 represents strong, favorable agreement.	
Lrng	Average response across 5 survey items related to satisfaction or favorable attitudes towards learning with OER. Values range from 1 to 5, where 1 represents less agreement and 5 represents strong, favorable agreement.	
DC1M (avg)	Efficacy scale for Digital Citizenship at time 1. Average response across 6 survey items related to students' belief in their ability to accomplish tasks related to digital citizenship	3 indicates belief that the student can accomplish the task without help, 2 indicates a belief that the student can accomplish the task with help, and 1indicates a belief to attempt the task as a next goal.
CW1M (avg)	Efficacy scale for Collaborative Work and Play with Ideas at time 1. Average response across 9 survey items related to students' belief in their ability to accomplish tasks related to collaborative work and play with ideas	
CTDV1M (avg)	Efficacy scale for Critical, Quantitative Thinking and Data Visualization at time 1. Average response across 11 survey items related to students' belief in their ability to accomplish tasks related to Critical, Quantitative Thinking and Data Visualization	
PCM1M (avg)	Efficacy scale for Programming and Computational Methods at time 1. Average response across 12 survey items related to students' belief in their ability to accomplish tasks related to digital citizenship	
DC2M (avg)	Efficacy scale for Digital Citizenship at time 2.	
CW2M (avg)	Efficacy scale for Collaborative Work and Play with Ideas at time 2.	
CTDV2M (avg)	Efficacy scale for Critical, Quantitative Thinking and Data Visualization at time 2.	
PCM2M (avg)	Efficacy scale for Programming and Computational Methods at time 2.	
DC3M (avg)	Efficacy scale for Digital Citizenship at time 3.	
CW3M (avg)	Efficacy scale for Collaborative Work and Play with Ideas at time 3.	
CTDV3M (avg)	Efficacy scale for Critical, Quantitative Thinking and Data Visualization at time 3.	
PCM3M (avg)	Efficacy scale for Programming and Computational Methods at time 3.	